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APPENDIX

Localities Cited

CAS loc. 1345, Texas Springs, 3.2 km E of Horsetown on road leading to Centerville, SW side of road, SW ¼ sec. 28, T31N, R5W, MDBM, Redding Quad, Shasta Co., Calif. Coll.: F. M. Anderson. Lower Cretaceous (Albian), Budden Canyon Formation.

CAS loc. 31918, Thompson Creek, 182.9 m W and 365.8 m N of SE ¼ sec. 20, T8N, R2W, MDBM, Monticello Dam Quad, Yolo Co., Calif. Coll.: W. E. Kennett, 1943. Just above base of Upper Cretaceous (Turonian), Yolo Formation.

CAS loc. 61856 (*ex* CAS loc. 445-A), Fitch Ranch, 3.2 km W of Phoenix, 0.8 km S of Fitch's house, Medford Quad, Jackson Co., Oregon. Upper Cretaceous (Cenomanian/Turonian), Blue Gulch Member, Hornbrook Formation.

CAS loc. 61918 (*ex* S. G. Clark loc. 251), near Gualala, sec. 27(?), T11N, R15W, MDBM, Gualala Quad, Mendocino Co., Calif. Coll.: S. G. Clark. Upper Cretaceous (Maastrichtian), Gualala Group.

LACMIP loc. 28757, Thompson Creek, 640.5 m E of Napa-Yolo Co. line, 823.5 m N of Putah Creek, near mouth of small E flowing ravine, SE ¼ SE ¼ sec. 20, T8N, R2W, MDBM, Monticello Dam Quad, Yolo Co., Calif. Coll.: P. W. Reinhart. Upper Cretaceous (Turonian), Yolo Formation, 3425 m below top of exposed Chico Formation.

LACMIP loc. 10903 (*ex* CIT loc. 1622), near Ashland, along irrigation ditch 45.7–61 m above and to the SW of the Southern Pacific RR tracks at a point 6.43 km SE of U.S. Highway 99 bridge over Ashland Creek, Ashland, Jackson Co., Oregon, near midpoint of W boundary sec. 24, T39S, R1E, WBM, Medford Quad, Oregon. Coll.: W. P. Popenoe and W. A. Findlay, September 1933. Upper Cretaceous (Turonian), Hornbrook Formation.

MGS loc. 129, Chapelville area, 1464 m NE of town on State Highway 348, NE ¼ NE ¼ sec. 29, T7S, R7E, CBM, Ratliff Quad, Lee Co., Miss. Coll.: D. T. Dockery III. Upper Cretaceous (Campanian), "Chapelville fossiliferous horizon" within the Tupelo Tounge sequence of the Coffee Formation.

SDSNH loc. 3162, Carlsbad area, locality (now covered by Faraday Avenue) was exposed during development of Carlsbad Research Center, SW of El Camino Real, S of Letterbox Canyon and N of Palomar Airport, 33°08′02″N, 117°16′41″W, San Luis Rey Quad, San Diego Co., Calif. Coll.: B. O. Riney, T. A. Deméré, and M. A. Roeder, March–May 1982. Upper Cretaceous (Campanian/Maastrichtian), Point Loma Formation.

SDSNH loc. 3162-A, Carlsbad area, at the base of stratigraphic section measured at SDSNH loc. 3162, approximately 6.1 m below a calcareous marker bed. Coll.: B. O. Riney, T. A. Deméré, and M. A. Roeder, March–May 1982. Upper Cretaceous (Campanian/Maastrichtian), Point Loma Formation.

SDSNH loc. 3162-B, Carlsbad area, 2.1–3.9 m below a calcareous marker bed in measured stratigraphic section at SDSNH loc. 3162. Coll.: B. O. Riney, T. A. Deméré, and M. A. Roeder, March–May 1982. Upper Creta-

ceous (Campanian/Maastrichtian), Point Loma Formation.

SDSNH loc. 3162-M, Carlsbad area, near top of exposed stratigraphic section measured at SDSNH loc. 3162. Coll.: B. O. Riney, T. A. Deméré, and M. A. Roeder. Upper Cretaceous (Campamian/Maastrichtian), Point Loma Formation.

SDSNH loc. 3392, Carlsbad area, N of Palomar Airport, roadcut along W side of College Blvd., approximately 424 m S of intersection with El Camino Real, 33°08′21″N, 117°17′02″W, San Luis Rey Quad, San Diego Co., Calif. Coll.: SDSNH field party May 1987. Upper Cretaceous (Campanian/Maastrichtian), Point Loma Formation.

SDSNH loc. 3405, Carlsbad area, N of Palomar Airport, excavation for College Blvd., approximately 242–485 m S of intersection with El Camino Real, 33°08′21″N, 117°17′02″W, San Luis Rey Quad, San Diego Co., Calif. Coll.: B. O. Riney, M. A. Roeder, and R. Q. Gutzler, April–May 1987. Upper Cretaceous (Campanian/Maastrichtian), Point Loma Formation.

SDSNH loc. 3454, Carlsbad area, N of Palomar airport, excavation for College Blvd., approximately 153 m N of College Blvd. and Faraday Ave. intersection, 33°08′11″N, 117°17′02″W, San Luis Rey Quad, San Diego Co., Calif. Coll.: B. O. Riney and M. A. Roeder, April–May 1987. Upper Cretaceous (Campanian/Maastrichtian), Point Loma Formation.

UCLA loc. 7288, Bellinger Hill area, large block displaced to S side of Bellinger Lane and about 0.19 km E of crest of Bellinger Hill by road improvement, approximately 793 m N and 884 m E of NE corner sec. 5, T38S, R2W, in parcel 92, T37S, R2W, WBM, Medford Quad, Jackson Co.. Oregon. Coll.: W. P. Popenoe, R. B. Saul, L. R. Saul, R. B. Saul, and R. L. Saul, 17 June and 23 August 1975. Upper Cretaceous (Cenomanian), Osburger Gulch Sandstone Member, Hornbrook Formation.

USGS loc. 518, bank of Postoak Creek at N edge of Corsicana, Navarro Co., Texas: approximately same as USGS loc. 17012. Coll.: C. A. White and C. B. Boyle, 1890; G. Scott, 1935. Upper Cretaceous (Maastrichtian), Nacatoch Sand, Navarro Group.

USGS loc. 761, near Kaufman on W facing slope of Kings Creek valley, 0.8 km from courthouse where wagon road goes down to Kings Creek, and along E side of creek for 4.8 km S of Kaufman, Kaufman Co., Texas; approximately same as USGS loc. 7545. Coll.: T. W. Stanton, 1890; L. W. Stephenson, 1911. Upper Cretaceous (Maastrichtian), Nacatoch Sand, Navarro Group.

USGS loc. 17702, S side of Chesapeake and Delaware Canal, 91.5 m W of Conrail's Chesapeake and Delaware Canal bridge, northern Delaware. Coll.: C. W. Carter, 1935–37. Upper Cretaceous (Campanian), Marshalltown Formation.

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THE VELIGER

New Paleogene Siliquariid and Vermetid Gastropods from the Pacific Coast of Southwestern North America

by

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Abstract. Two new species of the siliquariid gastropod *Tenagodus* and one new species of the vermetid gastropod ?*Serpulorbis* are described from Paleogene strata along the Pacific coast of southwestern North America. The new species of *Tenagodus* are the first reports of this genus from the Pacific coast of North America. The new species of ?*Serpulorbis* is the earliest occurrence of a vermetid from the Pacific coast of North America.

Tenagodus ***californiensis*** sp. nov. is from outer shelf siltstone in the upper Paleocene Coal Canyon Formation, Santa Monica Mountains, and from similar deposits in the upper Paleocene Santa Susana Formation, Simi Hills, southern California. This new species is the earliest occurrence of *Tenagodus* in North America. *Tenagodus* ***bajaensis*** sp. nov. is from inner shelf sandstone in the lower Eocene part of the Bateque Formation, Baja California Sur, Mexico. ?*Serpulorbis* ***llajasensis*** sp. nov. is from shelf-break glauconitic sandstone in the lower middle Eocene part of the Llajas Formation, Simi Valley, southern California.

INTRODUCTION

Previously, there have been no confirmed reports of siliquariid or vermetid gastropods in the Paleogene fossil record of the Pacific coast of North America. Identification of these gastropods requires inspection of the entire individual or colony (KEEN, 1961), but they are not easily collected as complete specimens. This is especially true when they are in well-indurated rocks like those prevalent in Paleogene deposits of the Pacific coast of North America. Most specimens are collected as fragments and then, understandably, considered by workers to be unidentifiable calcareous tubes formed by tubicolous annelids, and not worthy of systematic treatment. Discovery of nearly complete siliquariid and vermetid specimens in well-indurated Paleogene deposits of southern California and Baja California Sur, Mexico (Figure 1), therefore, is especially noteworthy.

Abbreviations used for catalog and/or locality numbers are as follows: CSUN, California State University, Northridge; IGM, Instituto de Geología, Universidad Nacional Autónoma Museum de México; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; UCLA, University of California, Los Angeles (collections now housed at LACMIP).

MATERIALS

About 60 specimens of *Tenagodus* ***californiensis*** sp. nov. were found in the Coal Canyon Formation at locality UCLA 7108 (=locality CSUN 354). This locality is on the west side of the south fork of Garapito Creek at 1200 ft elevation (366 m), 436 m (1430 ft) south and 68.5 m (225 ft) east of the northeast corner of section 5 (projected), T1S, R16W, San Vicente y Santa Monica Grant, Topanga quadrangle (7.5 minute), 1952, photorevised 1967, Santa Monica Mountains, Los Angeles County, southern California. A detailed index map of this locality is given in SQUIRES (1980).

Three specimens of *Tenagodus* ***californiensis*** were also found in the lower middle part of the Santa Susana Formation at locality CSUN 1290. This locality is on the east side of Bus Canyon at 1250 ft elevation (381 m), 381 m (1250 ft) north and 372 m (1220 ft) west of the southeast corner of section 28, T2N, R18W, Thousand Oaks quadrangle (7.5 minute), 1950, photorevised 1967, Simi Hills, Ventura County, southern California.

Three specimens of *Tenagodus* ***bajaensis*** sp. nov. were found in the Bateque Formation at locality CSUN 1291a. This locality is on the south side of a minor canyon near the southern end of Mesa La Salina at 120 m elevation,

at 112°56′13″W and 26°40′N, San Jose de Gracia quadrangle (1:50,000), number G12A64, 1983, Baja California Sur, Mexico.

Five specimens of *?Serpulorbis* ***llajasensis*** sp. nov. were found in the LACMIP collections of the "Stewart bed" that crops out near the middle of the Llajas Formation at locality UCLA 2313 (=locality CSUN 374). This locality, which is in a tributary to Las Llajas Canyon, is at elevation of 1700 ft (518 m) on a small cliff on the south side of a side canyon, 594 m (1950 ft) north and 556 m (1825 ft) east of the southeast corner of section 29, T3N, R17W, Santa Susana quadrangle (7.5 minute), 1951, photorevised 1969, northern Simi Valley, Ventura County, southern California. A detailed index map of this locality is given in SQUIRES (1983, 1984).

DEPOSITIONAL ENVIRONMENTS AND GEOLOGIC AGES

The abundant specimens of *Tenagodus* ***californiensis*** in the Coal Canyon Formation at locality UCLA 7108 were found as an intergrown mass in a concretion within siltstone. Associated macrofauna, which was described by SQUIRES (1980), is sparse and includes several genera of bivalves and gastropods, and one genus each of heart urchin and crab. Neither the intergrown mass of *Tenagodus* nor the associated macrofauna show signs of abrasion due to post-mortem transport, and they were interpreted by SQUIRES (1980) to be *in situ* in a shallow subtidal environment that would be equivalent to the outer shelf environment as defined by BOTTJER & JABLONSKI (1988). SQUIRES (1980) reported the deposits at this locality to be late Paleocene in age. The common presence of *Turritella infragranulata* Gabb, 1864, at this locality is further evidence of such an age because this turritellid is probably indicative of the upper middle to upper Thanetian Stage (late Paleocene) (SAUL, 1983).

The few specimens of *Tenagodus* ***californiensis*** in the Santa Susana Formation at locality CSUN 1290 were found as isolated but nearly complete individuals within a 2.5-m-thick muddy siltstone unit interbedded within a more sparsely fossiliferous very fine-grained sandstone sequence. Associated macrofauna is uncommon and included several genera of infaunal bivalves, two genera of terebratulid brachiopods, and two genera of gastropods. The bivalves and brachiopods are articulated and some show growth series. No suitable hard substrate was found that could have provided attachment for the brachiopods and the specimens of *Tenagodus*. Unlike the bivalves, the brachiopods may have been transported, but the amount of post-mortem transport was not great because indications of significant abrasion were absent. The specimens of *Tenagodus* may have undergone a similar amount of post-mortem transport, or they may be essentially *in situ* if they had lived embedded in sponges like certain modern species of *Tenagodus* that have been reported (MORTON, 1955; GOULD, 1966; R. Bieler, personal communication) in the western Atlantic. The deposits at locality 1290 plot on PARKER's (1983:figs. 4, 6) measured section A of the Santa Susana Formation in Bus Canyon at about 600 m above the base of the underlying Simi Conglomerate. PARKER (1983) interpreted this part of the Santa Susana Formation to have been deposited in an offshore shelf environment that would be equivalent to outer shelf deposits as defined by BOTTJER & JABLONSKI (1988). This part of the Santa Susana Formation is correlative to the upper Paleocene Thanetian Stage based on the presence of calcareous nannofossils found by FILEWICZ & HILL (1983) and planktonic foraminifera found by HEITMAN (1983). Age-diagnostic macrofossils at locality 1290 are the bivalve *Pholadomya* (*Bucardiomya*) *mounti* Zinsmeister and the gastropod *Fulgoraria* (*Psephaea*) *zinsmeisteri* Mount. ZINSMEISTER (1983) reported these species from upper Paleocene strata elsewhere in the Santa Susana Formation, Simi Hills.

The few specimens of *Tenagodus* ***bajaensis*** in the Ba-

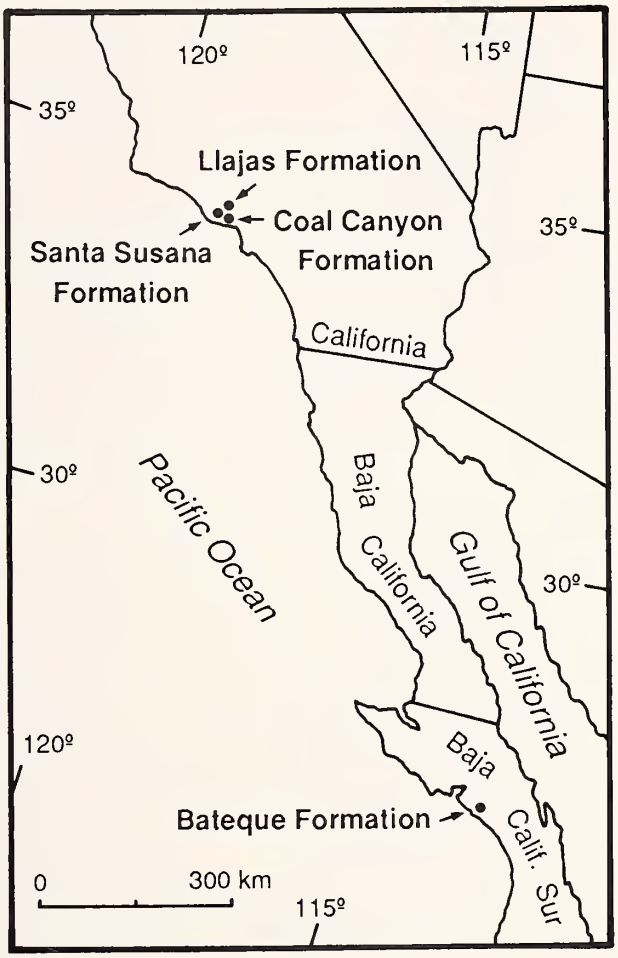

Figure 1

Stratigraphic occurrences of the new Paleogene siliquariid and vermetid gastropods.

teque Formation at locality 1291a were found as isolated but mostly complete individuals in a lens consisting of fossiliferous very fine-grained sandstone surrounded by bioturbated very fine-grained sandstone. Associated macrofauna included several genera of gastropods, and one genus each of scaphopod and solitary scleractinian coral. In addition, abundant fragments of discocyclinid foraminifera were present. The lens represents a concentration of fossil material, much of which is fragmental. This *Tenagodus*-bearing lens is interpreted to be a storm deposit in an inner shelf environment, as defined by Bottjer & Jablonski (1988). The amount of post-mortem transport of the larger fossils, like the specimens of *Tenagodus,* however, was not great because the amount of abrasion is low. Lithologically and paleontologically, the deposits at locality 1291a are similar to exposures of the Bateque Formation about 10 km to the north at locality CSUN 1220b. Geologic details of that particular locality are given in Squires & Demetrion (1990), who reported that the deposits at locality 1220b are correlative to the lower Eocene Ypresian Stage based on the presence of planktonic foraminifera.

The rare specimens of *?Serpulorbis* ***llajasensis*** in the Llajas Formation at locality UCLA 2312 were found in the 1-m-thick silty glauconitic sandstone of the "Stewart bed." The rocks at this locality are richly fossiliferous and have been the subject of extensive macropaleontologic work by Squires (1983, 1984). The "Stewart bed" represents an *Eocernina-Turritella-Crassatella-?Trochocyathus* paleocommunity with at least 50 species of macrofossils that lived near the shelf-slope break (Squires, 1984). The bed, which is 355 m above the base of the formation, is correlative to the middle Eocene Lutetian Stage based on the presence of calcareous nannofossils found by Filewicz & Hill (1983).

SYSTEMATIC PALEONTOLOGY

Superfamily Cerithiodea Fleming, 1822

Family Siliquariidae Anton, 1838

Genus *Tenagodus* Guettard, 1770

Type species: By subsequent designation (Sacco, 1896), *Serpula anguina* Linné, 1758, Recent, Indian Ocean.

Discussion: As mentioned in Gould (1966), older classifications placed all irregularly coiled mesogastropods in the family Vermetidae, but Morton (1951) removed the Siliquariidae from this vermetid complex. R. Bieler (personal communication), who is currently reviewing the anatomy and biology of certain members of the siliquariids, now recognizes two groups in this family: namely, those with a slit (*Tenagodus* and *Pyxipoma*) and those without a slit (*Stephopoma*).

Gould (1966) stated that because Guettard (1770) used a nonbinomial designation for the type species in naming *Tenagodus,* the name is invalid and *Siliquaria* Bruguière, 1789, should be used instead. However, according to ICZN Article 11(c)(i), the binomial form of Linné (1758) is not required in the formation of a genus name in works published before 1931; hence, the name *Tenagodus* is valid.

Wenz (1939) and Davies (1971) reported the geologic range of *Tenagodus* as Middle Triassic to Recent.

Tenagodus ***californiensis*** Squires, sp. nov.

(Figures 2–5)

Diagnosis: A *Tenagodus* with about 14 coarse spiral ribs on outer side of each whorl and about 10 fine spiral ribs on inner side of each whorl.

Description: Shell medium size, up to 65 mm length (incomplete) and 6.5 mm width (incomplete). Solitary or colonially intergrown. Protoconch missing. Loosely spirally coiled in juvenile stage, irregular to tubelike in later stages. Shell with about 14 slightly beaded coarse spiral ribs on outer side of each whorl, coarsest at maximum curvature of outer side, and about 10 fine spiral ribs on inner side of each whorl. Interspaces between coarse spiral ribs rarely with one secondary spiral rib. In some specimens, spiral ribs on inner side of each whorl also coarse. Longitudinal slit in posterior part of each whorl, usually open in juvenile stage but commonly filled in later stages and forming angulation on tube.

Discussion: *Tenagodus* ***californiensis*** is most similar to *T. (Agathirses) striatus* (Defrance, 1827:214; Deshayes, 1861:292, pl. 10, figs. 7, 14; Cossmann & Pissarro, 1910–1913:pl. 22, fig. 132-1; Cossmann, 1912:147, pl. 10, fig.

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Explanation of Figures 2 to 10

Figures 2 to 5. *Tenagodus* ***californiensis*** sp. nov. Figure 2. Holotype, LACMIP 8086, internal mold, lateral view, locality CSUN 1290, ×1.7. Figures 3 and 4. Paratype, LACMIP 8087, locality UCLA 7108, ×3. Figure 3. Oblique dorsal view. Figure 4. Lateral view. Figure 5. Paratype, LACMIP 8088, lateral view of inner side of whorl, locality UCLA 7108, ×3.

Figures 6 to 8. *Tenagodus* ***bajaensis*** sp. nov., locality CSUN 1291a. Figure 6. Holotype, IGM 5102 = plastoholotype, LACMIP 8089, lateral view, ×2.6. Figures 7 and 8. Paratype, IGM 5103 = plastoparatype, LACMIP 8090. Figure 7. Lateral view, ×1.4. Figure 8. Oblique dorsal view of same specimen shown in Figure 7 but with the upper spire whorls removed to expose the longitudinal slit, ×1.8.

Figures 9 and 10. *?Serpulorbis* ***llajasensis*** sp. nov., locality UCLA 2312. Figure 9. Holotype, LACMIP 8091, lateral view of three weathered colonial specimens, ×3. Figure 10. Paratype, LACMIP 8092, lateral view, ×3.


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16; GLIBERT, 1933:49, pl. 3, fig. 4) from middle Eocene (Lutetian Stage) strata of the Paris Basin, France. A comparison of *T.* ***californiensis*** with four UCMP Cloez collection specimens of *T.* (*A.*) *striatus* from Chaussy, Oise, Paris Basin and with three specimens of *T.* (*A.*) *striatus* collected by the author from Villiers-St.-Frederic, Paris Basin, revealed that *T.* ***californiensis*** differs in the following features: presence of numerous fine spiral ribs on the inner side of each whorl rather than being smooth, ribs are coarser and more closely spaced on outer side of each, much less development of a secondary spiral rib in the interspaces, a slit that becomes partly filled rather than remaining open throughout growth, and no development of cancellate ornamentation.

Tenagodus ***californiensis*** and the slightly younger *T.* ***bajaensis*** are the first reports of this genus from the Pacific coast of North America. The only other Paleogene species of *Tenagodus* known from North America are two species from upper middle Eocene strata in the southeastern United States (PALMER & BRANN, 1966; TOULMIN, 1977). Neither is similar to the new species.

Etymology: The specific name is for California.

Material: About 63 specimens, 60 of which were an intergrown mass. The other three are solitary forms.

Occurrence: Upper Paleocene Thanetian Stage. Coal Canyon Formation, Santa Monica Mountains, southern California, locality UCLA 7108; lower middle Santa Susana Formation, Simi Hills, southern California, locality CSUN 1290.

Repository: Holotype, LACMIP 8086, locality CSUN 1290; paratypes, LACMIP 8087 to 8088, locality UCLA 7108.

Tenagodus ***bajaensis*** Squires, sp. nov.

(Figures 6–8)

Diagnosis: A *Tenagodus* with scaly looking, fairly low but elongate hollow spines.

Description: Shell medium size, up to 52 mm length (incomplete) and 10 mm width (incomplete). Solitary. Protoconch missing. Loosely spirally coiled in juvenile stage, irregular in later stages. Outer side of each whorl with about 6 strong spiral ribs with scaly looking, fairly low but elongate hollow spines which, when eroded down to base, form horizontal "V" shape with point of "V" directed adapically. Fairly wide interspaces between ribs. Longitudinal slit in posterior part of each whorl and open throughout; possible row of holes in slit in juvenile stage.

Discussion: *Tenagodus* ***bajaensis*** is similar to *T.* (*Agathirses*) *faujasi* (DESHAYES, 1861:290, pl. 10, figs. 3–4; COSSMANN & PISSARRO, 1910–1913:pl. 22, fig. 132-3) from middle Eocene (Lutetian Stage) strata of the Paris Basin, France. A comparison between *T.* ***bajaensis*** and two UCMP Cloez collection specimens of *T.* (*A.*) *faujasi* from Chaussy, Paris Basin, revealed that *T.* ***bajaensis*** differs in the following features: spines are coarser, more laterally elongate, not as projecting (especially on ventral side of each whorl), and have a much more overlapping scaly look.

Etymology: The specific name is for the peninsula of Baja California, Mexico.

Material: Three solitary specimens.

Occurrence: Lower Eocene, Ypresian Stage. Bateque Formation, Baja California Sur, Mexico, locality CSUN 1291a.

Repository: Holotype, IGM 5102 = plastoholotype, LACMIP 8089; paratype, IGM 5103 = plastoparatype, LACMIP 8090, locality CSUN 1291a.

Superfamily VERMETOIDEA Rafinesque, 1815

Family VERMETIDAE Rafinesque, 1815

Genus *Serpulorbis* Sassi, 1827

Type species: By monotypy, *Serpulorbis polyphragma* Sassi, 1827, Recent, Mediterranean Sea.

Discussion: Recent research by HEALY (1988) on sperm structure indicates a separate superfamily Vermetoidea for the family Vermetidae.

As fossil material, the only morphologic distinction between the genera *Serpulorbis* and *Vermetus* Daudin, 1800, is that *Serpulorbis* has no operculum whereas *Vermetus* has a corneous one. Unfortunately, corneous material is rarely preserved in the fossil record. Currently, the only criterion available to distinguish these two genera is the rather dubious one of geologic age range. WENZ (1939), KEEN (1961), and DAVIES (1971) reported the geologic range of *Serpulorbis* to be Upper Cretaceous?, Eocene to Recent. GARDNER (1933) and PALMER & BRANN (1966), however, reported lower and upper Paleocene species. WENZ (1939) and DAVIES (1971) reported the geologic range of *Vermetus* to be Pliocene to Recent. SMITH (1986), however, reported a middle Miocene species.

?*Serpulorbis* ***llajasensis*** Squires, sp. nov.

(Figures 9, 10)

Diagnosis: A *Serpulorbis*-like vermetid with noded cancellate ornamentation in which the collabral costae are the same strength as the spiral ribs.

Description: Shell small size, up to 28 mm length (incomplete) and 3.5 mm width (incomplete). Solitary or colonially intergrown. Protoconch missing. Loosely spirally coiled in early juvenile stage, tubelike in later stages. Shell covered with closely spaced (1 every mm) prominent collabral costae, nodose where intersecting 10 equal-strength spiral ribs covering the shell, producing cancellate